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The Welland Canals

Links in the World's Greatest Inland Waterway

The Welland canal has always been looked upon as the principal link in the great chain of inland water transportation extending from the Atlantic ocean via the St. Lawrence river and the Great Lakes to Fort William, Port Arthur and Duluth at the head of lake Superior, a distance of about 2,000 miles—the Main Grain Lane of North America to Europe.

The canal crosses the Niagara peninsula about ten miles west of Niagara falls and connects lake Erie with lake Ontario, whose difference in level at extreme low water is $325\frac{1}{2}$ feet.

Niagara falls and lake Erie.—On his return journey from the Andaste Indians on the Susquehanna river to Huronia, Etienne Brûlé evidently saw Niagara falls about 1616 or 1617, as they are shown on Champlain's map of 1632, and it is generally recognized that much of the information on the map must have been furnished by Brûlé. The first announcement to the world of the existence of the celebrated falls must, therefore, be credited to Champlain, although he never saw them. La Roche Daillon visited the Neutral Nation north of lake Erie in 1626-27 and Brébeuf and Chaumonot in 1639-40 and 1640-41, but there is no evidence that any of the three saw lake Erie or Niagara falls. In the *Relations* of 1641, Lalement accurately describes the lake and falls, but adds no information as to the character of the falls beyond that narrated by the Indians to Champlain. Who was the first European to see the falls will never be known as he was probably among the *coureurs de bois*, or perhaps some missionary who did not leave a written record. Dollier de Casson and René de Gallinée were in this region in 1669 and spent the winter of 1669-70 on the north shore of lake Erie. Gallinée in his journal speaks of passing the mouth of the Niagara river and hearing the roar of the falls and on his map of 1670, says that according to the report of the Indians, the falls have a height of 200 feet. In 1678 Hennepin visited Niagara falls and describes them. Lalement tells us that the name given to the river by the people through whose territory it flowed was Onguaahra, but he gives no meaning. The word has many forms and towards the end of the eighteenth century was given its

present form "Niagara." The falls have always been a subject of peculiar and reverend admiration, and the work of man in overcoming this imposing phenomenon is naturally surrounded by an atmosphere of greater importance than accords to works of less magnitude. The rapids of the St. Lawrence river could be overcome by towing or by short portages, but those of the Niagara defied such easy conquest. Previous to the construction of the canal, all freight had to be transported overland from Queenston to the Chippawa creek.

It is not definitely known who first proposed the construction of the Welland canal, but the first step towards the practical solution of the problem was made in 1816 when Colonel Robert Nichol succeeded in introducing to the Parliament of Upper Canada a Bill providing funds for a survey of the water routes between lakes Erie and Ontario, and between lake Ontario and Lower Canada. The Bill, however, never became law and it remained for the people of the Niagara District, under the inspiration and energetic leadership of the Honourable William Hamilton Merritt to form the Welland Canal Company and build the First Welland canal as a private enterprise.

THE FIRST WELLAND CANAL

On November 30, 1924, there was unveiled at Allanburg, Ontario, a cairn marking the spot where, one hundred years before, the first sod of the Welland canal was turned by Mr. George Keefer, President of the Welland Canal Company.

The canal was built via the Twelve Mile creek from Port Dalhousie, on lake Ontario, to Port Robinson on the Chippawa creek, from which point boats descended the creek to the Niagara river, and thence ascended the river to lake Erie. It had 40 wooden locks, each 110 feet long, 22 feet wide, with 8 feet of water on the sills. The summit level, higher than lake Erie, was supplied with water by a feeder canal from the Grand river at Dunnville.

This canal was completed in 1829, when two schooners, the *Annie* and *Jane of York* (Toronto) Upper Canada, and the *R. H. Boughton* of Youngstown, Ohio, were taken through the waterway. By 1833, an extension of the canal from Port Robinson to Port Colborne on lake Erie was completed, but the summit level was still supplied from the Grand river. This route had a length of $27\frac{1}{2}$ miles from lake to lake.

THE SECOND WELLAND CANAL

In 1837 the Government of Upper Canada, which had loaned considerable money to the Welland Canal Company, converted its loans into stock and, in 1841, purchased the entire canal from the private stockholders. The Government at once decided to enlarge the canal for 9-foot navigation and to complete the St. Lawrence canals, which were necessary to overcome the various rapids between lake Ontario and Montreal. The 40 wooden locks were reduced to 27 by increasing the lifts of each. The new locks were built of cut stone and were each 150 feet long, $26\frac{1}{2}$ feet wide with 9 feet of water on the sills. This enlargement and the construction of the Port Maitland branch were begun in 1842 and when they were completed in 1845 they formed a new and shorter route between the lakes.

The section of the canal between the Feeder Junction (Welland) and Port Colborne was then enlarged for 9-foot navigation and opened for traffic in 1850.

The second canal between Port Dalhousie and Thorold remained in operation after the Third canal was completed, but since 1915 has only been used for power purposes. Its locks are still in existence. In 1853 its navigable depth was increased to 10 feet by raising the banks and the walls of the locks, but it was not until 1881 that the canal was fed from lake Erie at Port Colborne.

The original cost of construction, including the first enlargement, or the total expenditure prior to Confederation, July 1, 1867, was \$7,638,240.

THE THIRD WELLAND CANAL

Twenty-two years after Upper and Lower Canada had completed the 9-foot navigation between lake Erie and Montreal, the Dominion Government took up the question of inland navigation, and the Commission of 1871 recommended a uniform scale of navigation for the St. Lawrence route and the Welland canal with locks 270 feet long, 45 feet wide and 12 feet of water on the sills. This depth of water was later increased to 14 feet. The work of enlarging the Welland canal was carried out to these dimensions. This canal left lake Ontario at Port Dalhousie and climbed the escarpment east of the Second canal to Allanburg. From the latter place to Port Colborne it followed the route of the Second canal. Its twenty-six locks were built of

cut stone, with lifts of 12 to 14 feet. It was carried over the Chipawa creek at Welland by a cut stone aqueduct. This Third canal, $26\frac{3}{4}$ miles long, was opened to traffic for 14-foot navigation in 1887, and the St. Lawrence canals in 1901, when the Northwestern Steamship Company of Chicago placed a fleet of four steamers (2,000 tons capacity) in commission between Chicago and Europe. On more than one occasion the boats were loaded to slightly over the 14-foot limit.

The Third canal, up to March 31, 1931, cost for capital construction and permanent improvements \$30,864,172.40 and \$14,562,275.20 for operation, repairs and maintenance. These amounts do not include the original cost, enlargements and maintenance of the Port Colborne Elevator and breakwaters.

The St. Lawrence and Welland canals, between Montreal and lake Erie, cost Canada, up to March 31, 1931, \$72,857,205.27 on capital construction and permanent improvements, and \$34,945,017.58 for operation, repairs and maintenance. These amounts do not include the cost of constructing the Welland Ship canal, nor the cost and maintenance of the aids to navigation between Montreal and lake Erie, nor the cost and maintenance of the Port Colborne Elevator and breakwaters.

In 1901 the total tonnage passing through the Third canal was only about 620,000. In 1914, it had increased to 3,860,000, indicating that since the completion of the 14-foot navigation system in 1901, the St. Lawrence route had gradually drawn more heavily, year by year, upon the Great Lakes-Atlantic seaboard trade. As a result of the Great War taking many lake vessels into service on the high seas, traffic through the Third canal fell off from 3,860,000 tons in 1914 to 2,171,000 tons in 1919. Since the latter date, traffic through the canal has grown rapidly. In 1930, the last year the Third canal was in commission, the tonnage passed through the canal was 6,087,910. All of this freight was carried by vessels limited in length to 255 feet, and a beam not exceeding 44 feet. In 1932, the second year the Ship canal was in commission, the tonnage had increased to 8,537,460.

THE (FOURTH) WELLAND SHIP CANAL

The size of ships sailing the Great Lakes has at all times kept pace with the demand of water transportation but this growth has been entirely out of proportion with the navigation

facilities provided from lake Erie to Montreal by the short-sighted policy of 1871, a policy which left the Welland canal as much out of date in 1887 as it was when the improvements were begun in 1873. The tremendous growth of the eastern movement of grain and iron ore and the western movement of coal called for the building of vessels of much greater size than could be accommodated by the limited dimensions of the Third Welland and St. Lawrence canals which can now be considered as of little more than barge size. By the year 1928 vessels up to 633 feet long with a beam of 70 feet and a load draught of 20 feet were in use on the Great Lakes, but up to the opening of the Welland ship canal all of the Great Lakes freighters were confined in their movements between the head of the lakes and the harbours of lake Erie, where transfer of cargo to rail or to canal-size vessels became necessary.

The foregoing situation had by the beginning of the Twentieth Century called attention to the necessity for many further canal improvements being made to accommodate the largest of the Great Lakes' freighters, as well as large ocean ships. To this end, many extensive surveys were made during the last decade of the Nineteenth Century and the early years of the Twentieth to determine the feasibility and cost of such a waterway between lake Erie and Montreal.

Following the opening of the St. Lawrence route in 1901 for vessels drawing 14 feet of water, the Canadian Government began improvements to the Port Colborne entrance of the Welland canal. These consisted of deepening the harbour to 22 feet, constructing a million bushel modern concrete elevator (completed in 1908) and building large breakwaters. The execution of these works and public agitation for the building of a Canadian deep waterway via the Welland canal and St. Lawrence river route, as opposed to the Georgian bay and Ottawa river route, finally led to exhaustive surveys being made for a ship canal across the Niagara peninsula and the adoption of the Ten Mile creek location for the canal and the inception of the work by the Dominion of Canada in 1913.

So great has been the increased movement of grain through the Welland canal that the federal Government has twice found it necessary to add to the original elevator at Port Colborne, first in 1912-13 and again in 1923-24, each addition increasing the capacity by one million bushels. The elevator and its extensions were taxed to the limit of their 3,000,000 bushel capacity in 1925.

The route of the Fourth canal, or Welland Ship canal, departs radically from that of the three previous canals, particularly on the lake Ontario side of the Niagara peninsula. It leaves lake Ontario at a point (Port Weller) about three miles east of Port Dalhousie, the northern terminus of the previous canals, and follows in practically a straight line, due south along the valley of the Ten Mile creek to the foot of the Niagara escarpment at Thorold. This alignment is maintained in the ascent of the escarpment itself, and from the top of the escarpment the route of the previous canals is followed in a general way to Port Colborne.

The Ship canal crosses the Third canal below Lock No. 11, where the water level of both canals is at elevation 382·0 above mean sea-level. The Ship canal again crosses the Third canal below Lock No. 25, south of Thorold, where the water level of the two canals coincides at elevation 568·0.

Between Thorold and Allanburg a new cut has been made for the purpose of straightening the alignment of the canal between these points.

From Allanburg to Port Robinson, the Ship canal follows the alignment of the Third canal through a cut 80 feet deep (the summit of the Niagara peninsula) which has been widened to 200 feet on the bottom, with a depth of 25 feet.

From Port Robinson to Welland the Ship canal takes a much straighter and more direct course, to the east of the Third canal, following closely the west bank of the Chippawa creek, which has been diverted at several places to the east side of the canal.

At the city of Welland the summit level of the canal crosses the Chippawa creek (Welland river), a sluggish stream which has its source in the western part of the peninsula and flows in an easterly direction to discharge into the Niagara river at the village of Chippawa situated at the head of the rapids above the falls. As the summer level of the creek is six feet below the level of the canal, the waters of the creek are passed under the canal through a concrete siphon culvert which replaced the cut stone aqueduct that carried the Third canal across the creek. The aqueduct was removed when the excavation for the Ship canal prism was carried out at this place.

From Welland to Ramey's Bend, just north of Humberstone, the Third canal was enlarged and deepened, and to elimin-

ate the sharp curve known as "Ramey's Bend," the Ship canal was built from there on practically a straight alignment to the inner harbour of Port Colborne.

For the protection of the summit level of the canal a guard lock, No. 8, was built just north of the inner harbour of Port Colborne, through which ships have to pass from lake Erie into the summit level of the canal, which is maintained at a regulated level, elevation 560.0. Lock No. 8 is 1,380 feet long between its inner gates and has the standard width and draught of the other locks, but its lift is determined from day to day by the level of lake Erie, which is a vast expanse of shoal water and is consequently subject to rapid variations caused by wind direction. A difference in level as great as 11 feet has been observed at Port Colborne. The lift of the lock throughout the summer season is about 3 to 4 feet.

The total length of the Ship canal is 25 miles, or 27.7 miles between the outermost ends of Port Weller and Port Colborne harbours, and for all practical purposes of navigation it is a straight line throughout. The difference in level between lake Ontario and lake Erie is overcome by seven locks of $46\frac{1}{2}$ feet lift each. The direct line of the canal up the face of the escarpment, and the topography of the lower plateau, permitted the adoption of these high lifts, which constitute a peculiar feature in the design of the canal, and have no precedent in actual construction for locks of their size.

The dimensions of the locks are 859 feet long, between pintle centres of gates, 80 feet wide with 30 feet of water on the sills.

The first six miles of the canal south from lake Ontario traverse the slightly rising lower level of the peninsula, which is deservedly called the Garden of Canada because of its natural rolling beauty and intensively cultivated fruit lands. Located on this section of the canal are three single locks: No. 1 is at the south end of Port Weller Harbour, No. 2 is $1\frac{3}{4}$ miles farther on, and No. 3 is $2\frac{3}{4}$ miles south of Lock No. 2. These three locks raise ships $139\frac{1}{2}$ feet above lake Ontario and bring them to the foot of the Niagara escarpment.

The canal now climbs the escarpment, which has an abrupt rise of 186 feet, by means of four locks and without any deviation from the direct route. Three of these locks, Nos. 4, 5 and 6, are twin locks in flight to provide separate means of passage for up and down-bound ships. If there were only

one flight of locks serious delays to navigation would be constantly occurring. Ships on leaving Lock No. 6 cross a short stretch of canal prism to single Lock No. 7 in the town of Thorold. This short section of canal provides passing space for ships and eliminates for the present the necessity of a duplicate lock at this point.

From Lock No. 7 the summit level of the canal, sixteen miles long, crosses the remainder of the peninsula to Lock No. 8 at Port Colborne.

The canal prism has a minimum bottom width of 200 feet, and 310 feet on the water line. The sides of the prism have 2 to 1 slopes and where they were excavated in the dry are protected along the water line with slabs of concrete one foot thick that extend $7\frac{1}{2}$ feet below water level. Where the prism was excavated in the wet the slopes at the water level are protected against wave action by a thick layer of broken rock.

The canal to-day between Port Weller and Port Robinson is generally excavated to a minimum depth of 25 feet and between Port Robinson and Port Colborne to $27\frac{1}{2}$ feet depth, and the harbours of Port Weller and Port Colborne to 28 feet below standard low water level of the lakes. All the structures of the canal have, however, been built for an ultimate depth of 30 feet, which can be obtained at any time in the future, should the demands of navigation require it, by the simple process of dredging the canal reaches and harbours without interfering with navigation. Only 20 feet is at present available at low water level in the harbours and channels of the Upper Lakes. So, after a period of over one hundred years of canal construction across the Niagara peninsula it would appear that a waterway is now provided which is adequate not only to the requirements of to-day, but to those that may be made upon it for many years to come.

Crossing the canal at intervals are the swing, bascule and vertical lift bridges, which accommodate the numerous railway and highway traffic arteries which traverse the peninsula from east to west. The vertical lift bridges operate on the principle of the counterbalanced elevator and provide for the movable spans being lifted 120 feet clear above the water for the passage of ships. This type of bridge offers a much less restricted channel than that provided by the swing-bridge so common to navigable waterways.

DESCRIPTION OF CONSTRUCTION

For the purposes of construction, the canal was divided into eight sections. No. 1 Section is at the lake Ontario end and No. 8 Section is at the lake Erie end. During the autumn of 1913, Sections Nos. 1, 2, 3 and 5 were placed under contract. On Sections Nos. 1, 2 and 3 are the seven lift locks. Section No. 5 embraced the deepening and widening of the deep cut on the summit level between Allanburg and Port Robinson. Owing to the European War, the work on the canal practically ceased in 1916 and in 1918 the contracts let in 1913 were cancelled and the work entirely closed down. After the armistice, November, 1918, the Government decided to resume work on a small scale and arranged with the original contractors for the resumption of work on their former contracts for Sections Nos. 1, 2, 3 and 5. From January, 1919, the work was carried on under a cost-plus percentage basis in a more or less intermittent manner, due to labour troubles and other causes, until 1921 and 1922, when the cost-plus percentage contracts were cancelled and the work relet under unit price contracts and completed in 1933.

Considering the canal as a whole, the estimated quantities of the principal items of work involved in its construction are as follows:—

Rock excavation	9,282,000 cu. yds.
Earth excavation	52,818,000 cu. yds.
Watertight embankments .	5,099,000 cu. yds.
Concrete all classes.....	3,614,000 cu. yds.
Reinforcing steel	39,697,000 lbs.
Steel sheet piling.....	43,599,000 lbs.

PORT WELLER

As no harbour existed on lake Ontario at the mouth of the Ten Mile creek, now the terminus of the Welland Ship canal, an artificial harbour, Port Weller, was one of the necessities of construction. By means of a standard double-track railway, built and operated by the Government for the construction of the canal between lake Ontario and Thorold, the surplus excavation of this division of the canal was used to build two parallel embankments extending $1\frac{1}{2}$ mile out into lake Ontario. The harbour has a bottom width of 800 feet between the embankments which are protected at their outer ends by lines of concrete

cribs placed 400 feet apart to form the entrance to the harbour. Rock excavation dumped along the inner and outer slopes of the embankments protects them from erosion by lake storms.

A long line of concrete dock wall has been built along the west side of the harbour below Lock No. 1. On the east side opposite the dock wall of the west side there was built a dock wall for small boats and a pair of spare gates and also a slip for berthing the pontoon gate lifter during the season of navigation.

As previously stated, the present navigable depth of the harbour is 28 feet below standard low water of lake Ontario.

A Gate Dock is situated off Lock No. 1 Pond for the storage, overhaul and repair of the spare steel lock gates, and for wintering the gate lifter.

LOCKS

Locks Nos. 1, 2 and 3, located on the lower plateau, as described earlier, are practically identical, the walls are constructed of concrete monoliths, 82 feet high, 46 feet wide at the bottom and 16 feet at the top, reinforced over the culverts and passages. The foundation of all the locks is rock.

The locks are filled and emptied through small passages 3 feet wide by 4 feet high at the floor level, all leading into two large culverts running lengthwise along the base of the walls and emptying below the lower gates. These culverts have arched roofs, are 15 feet wide and 16 feet 6 inches high, and are fed from an intake situated in the east wall at the upper end of the lock. That an eight-car train with the latest type of locomotive could easily be accommodated in one of these culverts will give some idea of their size.

The flow through the intake is controlled by four Taintor valves 7 feet wide and 15 feet high, two of which supply the culvert in the east wall; and the other two, by means of a tunnel under the floor, feed the culvert in the west wall.

At the lower end of the culverts, the discharge is controlled by two Taintor valves of the same size as the intake valves. The locks can be filled or emptied in less than 8 minutes.

Locks Nos. 4, 5 and 6 are twin locks in one flight with a total lift of $139\frac{1}{2}$ feet. They are similar to the Gatun locks on the Panama canal which, though of somewhat larger dimensions, have only an aggregate lift of 85 feet.

Their great height is well illustrated by the height of the concrete wall at the north end of Lock No. 5; this, from the coping of Lock No. 5 to the bottom of Lock No. 4 amounts to 130·8 feet. The Horse Shoe falls at Niagara are 158 feet high.

The east and west locks of the flights are separated by a concrete wall 60 feet wide, at the base of which are two culverts 12 feet wide by 16 feet 6 inches high, the Taintor discharge valves being 6 feet wide and 15 feet high.

The culverts in the flight locks are continuous, so that the water from one lock discharges directly into the one below. The intakes are at the head of Lock No. 6.

The culverts in the east and west walls are supplied from an intake in the east wall at the upper end of Lock No. 6, and the culverts in the centre wall from intakes located in the upper end of the centre wall.

As Locks Nos. 5, 6 and 7 are built in rock cuts, it was found possible to reduce the thickness of the side walls at the bottom in Locks Nos. 5 and 6 to 23 feet and in Lock No. 7 to 26 feet, anchoring them to the rock by heavy steel anchor rods grouted into the rock, which system is also applied to the floors.

Lock No. 7 is a single lock practically the same as Locks Nos. 1, 2 and 3, but having double gates at each end, is somewhat longer.

At the upper end of each lock (except No. 8) a massive concrete breastwall, $46\frac{1}{2}$ feet high, is built across the lock chamber, and as the upper gates of the lock are erected on top of the breastwall it is impossible under any circumstances for an up-bound vessel entering the lock at the lower level to ram the upper gates.

In Locks Nos. 1 to 7 a mooring post gallery is provided in the walls of the locks, 29 feet below the top of the walls. Spiral staircases connect the galleries with the top of the walls. From the galleries lateral openings lead to the faces of the walls, where mooring posts are set in the floors of the openings for the use of ships. Experience has proven that these mooring facilities are not required. There are also tunnels 6 feet wide by 10 feet high running lengthwise of the lock walls just below coping level for electric and telephone cables, etc.

LOCK NO. 8

Lock No. 8, which is 1,380 feet long between the inner gates, is the longest lock in the world, being 68 feet longer than

the new lock on the North sea canal, Holland, and 30 feet longer than the two locks on the American side at Sault Ste. Marie.

This lock is situated at the inner end of Port Colborne Harbour and has been built to protect the summit level, 16 miles long, and to maintain a constant water level in this reach of the canal.

As this lock has only to take care of a maximum lift of 12 feet, the variation of the water level in lake Erie, elevation 568.0 to 580.0, the walls are only 44 feet 6 inches high.

The lock is filled from an intake in each side wall above the gate leading into culverts about 500 feet long, constructed in the walls at the south end of the lock; these culverts do not extend the whole length of the walls as in the other locks. The lock is emptied through similar culverts at the north end of the lock which discharge below the lower gates.

STEEL LOCK GATES

The operating gates for the locks are of the mitering horizontal girder type, sheathed on both sides and built entirely of steel, all leaves being 48 feet long and 5 feet thick. The lower gates are 82 feet high, and each leaf weighs about 490 tons. The upper gates are 35 feet 6 inches high, each leaf weighing about 190 tons, and the gates of Lock No. 8 and the Guard Gate are 44 feet 6 inches high and weigh 235 tons for each leaf.

Spare gates of each size have been provided. A pair of lower gate leaves is stored at a special dock below Lock No. 1 and the remainder in the Gate Dock, which has been constructed for the storage, repainting and repair of the gates, and the wintering of the pontoon gate lifter.

The leaves swing on a hemispherical nickel steel pintle mounted in a casting, which is seated on a base casting grouted into the concrete, and are anchored at the top to two structural steel anchorage frames, embedded in the concrete, by two forged links connected to the leaf by a hinge pin 10 inches in diameter.

The end bearings of the leaves are formed of oak timber for the 35 foot 6 inch and 44 foot 6 inch gates, and of forged steel bearing plates for the 82-foot gates, as the pressure was too great for the use of timber. The bearings at the wall end of the smaller gates, when they are closed, are in contact with cast iron hollow quoin bearings embedded in the concrete.

The quoin bearings for the 82-foot gates consist of forged steel bearing plates, fixed to steel castings, which are in turn connected to structural steel quoin bearing members embedded in the concrete.

The sills and fenders are all made of white oak timber.

All the steel gates are provided with Gowan steel safety castings, which are bolted and riveted to the mitre posts of the gates. These safety castings permit of any gate being opened at the mitre to the extent of four feet without becoming unshipped. This feature is expected to eliminate many accidents of the type that have occurred on the Third Welland canal and the St. Lawrence canals by reason of vessels getting out of control and ramming the gates.

Should the gates of Locks Nos. 6, 7 or 8 be carried away, serious damage might be caused to the canal and navigation interrupted for a long time; two pairs of gates have therefore been provided at each end of these locks, thus providing extra protection, as there would be little likelihood of both gates being carried away by a vessel.

UNWATERING GATES FOR LOCKS

As it is impossible to empty Locks Nos. 1 and 8 without pumping, owing to their being at lake level, unwatering gates have been provided at the lower end of Lock No. 1 and at both ends of Lock No. 8. Similar gates have also been erected at the lower end of Lock No. 4 to enable work to be done on one side of the flight locks without interfering with traffic on the other.

These gates are all made of Douglas fir timbers bolted together by nickel-steel bolts, and braced diagonally. The pintels, anchorages and sills are the same as those for the steel gates and the bearings in the hollow quoins are also the same as for steel gates of similar height.

The locks must be unwatered periodically for the purpose of inspection, painting and repairs. In the case of Locks Nos. 2 to 7 this can easily be done by emptying the canal reaches, but it has been necessary to provide electrically driven pumps for Locks Nos. 1 and 8 capable of emptying them in 10 hours.

CAPSTANS

Capstans, electrically operated, with local control have been provided at each end of the locks on both sides, primarily

for operating the gates, should there be any failure to the gate operating machinery. They are also available for towing or any other hauling work which may be necessary.

FENDERS

As it would be a serious matter if a gate were carried away by a vessel, fenders have been provided to protect the gates. These fenders consist of a $3\frac{1}{2}$ -inch diameter steel rope stretched across the lock about 70 feet above and below each lower gate and above each upper gate where no bridge crosses the upper entrance. The rope is carried across the lock chambers on a light structural steel arm which operates in a similar manner to a rolling lift bridge. Sufficient resistance is provided by passing these cables round fixed bollards and unwinding them from a friction drum to bring up any vessel before it strikes the gates. The fender is capable of stopping a vessel of 20,000 gross tons displacement, moving at a speed of $4\frac{1}{2}$ miles an hour.

The expenditure on the fenders has been fully justified, as on three occasions during the navigation season of 1932 they have prevented what might have been serious accidents, involving the possible carrying away of the lower gates of Locks Nos. 1, 3 and 7. In each case, owing to misunderstanding between the vessel's bridge and engine room the ship struck the fender but was stopped by the wire rope in a short distance.

As spare booms and ropes are kept in stock, their replacement takes a comparatively short time, and the obstruction to navigation, the cost of replacement of the fender, and damage to the vessel are infinitely less than if a gate were struck or carried away.

OPERATION OF LOCKS

The gates, valves and fenders of the locks are all operated electrically by remote control from control houses placed one at each end of the lock.

The control desks in the two houses are electrically interlocked with one another and the movement of the apparatus is indicated by signal lights.

Daylight colour signals are provided for signalling to the vessels when they can be allowed to enter the locks.

BUILDINGS

To be in keeping with the massive concrete construction of the locks, reinforced concrete buildings have been erected to house the gate and valve machinery. All the discharge valve houses and the intake valve houses of Lock No. 8 and the centre wall of Lock No. 6 have been provided with removable roofs, so that access can be obtained for the removal of the valves by use of an auxiliary derrick on the gate lifter. The side wall intake valve houses are provided with overhead travelling cranes and are of sufficient height to enable the valves to be hoisted out under cover.

The control rooms are furnished with large plate glass windows and are located in such a position that a clear view along the lock and its approaches can be obtained.

REGULATING WEIRS AND PONDS

As the volume of water required for a lockage is equal to that occupied by an area of $77\frac{1}{2}$ acres one foot deep, or 21,000,000 Imperial gallons, it has been necessary to provide a large pondage area above each lock, so that the canal levels will be lowered as little as possible when filling the locks. For this purpose, the configuration of the ground east of the canal has been fully utilized in forming ponds above the locks. That above Lock No. 1 has an area of 107 acres; Lock No. 2, 200 acres; and Lock No. 3, 150 acres. To secure the necessary pondage for the flight locks it has been necessary to construct an earth dam 3,500 feet long, with a maximum height of $80\frac{1}{2}$ feet, and with a concrete core wall. The area of this pond is 84 acres. The pond for Lock No. 7 covers an area of about 65 acres.

To maintain the water in the ponds and canal prism at a constant level, regulating weirs have been constructed, those for Locks Nos. 1, 2 and 3 being adjacent to the east wall of the locks just below the intake culverts of the locks.

The regulating weir for the pond supplying the flight locks is built on the line of the Third canal at the east end of Dam No. 6, while that for Lock No. 7 has been erected close to the lower end of the lock on the east side, but far enough away to allow for the doubling of Lock No. 7 should it be found necessary in the future. Both weirs discharge into the Third canal, which is utilized as a channel connecting the different ponds.

All regulating weirs have been provided with valves built in the base of the weirs, those in Weirs Nos. 1, 2 and 3 are

of the Stoney sluice type, 15 feet wide by 11 feet, 6 inches high, there being five valves in Weir No. 1, 4 in Weir No. 2, and 2 in Weir No. 3.

Weir No. 6 has been provided with two Stoney valves and one Taintor valve 6 feet wide by 15 feet high, while Weir No. 7 has three Taintor valves each 7 feet wide by 15 feet high.

The Stoney valves in all weirs are arranged to open automatically by the operation of float switches, should the water in the ponds above rise over a certain height, thus preventing the possibility of the water overtopping the banks.

The spillway channels below the weirs are concrete lined and those for Weirs 1, 2 and 3 have a secondary weir at the lower end. These weirs are intended to back up the water in the raceway to a sufficient height to submerge the valves in the Regulating Weirs during the winter.

GUARD GATE AND SAFETY WEIR

As a further precaution for the safe and continuous operation of the canal, a guard gate and safety weir have been constructed about three-quarters of a mile above Lock No. 7 in addition to the double gates at the head and foot of Locks Nos. 6 and 7. The safety weir, built for passing the water supply of the canal around the guard gate is equipped with twelve Taintor valves, each 15 feet wide by 18 feet high. The valves are electrically operated from the control room of the guard gate and can all be closed in a few minutes. The operation of the guard gate is also so interlocked electrically with the operation of the upper gates of Lock No. 7 that the guard gate and the upper gates of Lock No. 7 cannot be opened simultaneously.

The guard gate and safety weir not only protect the lock division of the canal and the country north of Thorold from flooding by cutting off the waters of the summit level (16 miles long) of the canal, in the event of the gates of Lock No. 7 being carried away, but they can also be closed when necessary to unwater the canal reach between them and Lock No. 7 for repairs to the gates and valves, etc., of the lock.

SUPPLY WEIR

The Third canal, between Port Colborne and Ramey's Bend, has been abandoned for navigation, and is now being

used as a raceway to supply the Ship canal with water. The flow through this channel is controlled by the supply weir built across it on the alignment of Main street, Humberstone. The weir is equipped with ten Taintor valves, 15 feet wide, by 14 feet high, electrically controlled from the lower control room of Lock No. 8. The upper part of the weir is designed as a roadway, 30 feet wide with two five-foot sidewalks.

CHIPPAWA CREEK

The first three Welland canals were carried over the Chippawa creek at the city of Welland by aqueducts. The cut stone aqueduct of the Third canal has been replaced by a concrete inverted siphon culvert that passes the waters of the creek under the Ship canal. The culvert is located just north of the site of the aqueduct of the Third canal and consists of six tubes, each 22 feet in diameter, and 353 feet long between the centres of the vertical end shafts of the culvert.

There was considerable difficulty in carrying out the work of building this culvert, as its foundations are at an approximate depth of 75 feet below normal water level of the canal. A special cofferdam was built with steel sheet piling driven in a series of cells interlocked with one another and filled with clay, enclosing the area in which the new culvert was built. As the traffic on the Third canal could not be interrupted it was widened on the east side to give sufficient waterway past the cofferdam.

Nearly 18,000,000 pounds of steel sheet piling and 5,000,000 board feet of timber bracing were used in supporting the sides of the excavation, and 235,000 lineal feet of timber piling, driven down to rock, were used in foundations.

Should any of the tubes silt up, provision has been made for unwatering them two at a time by putting in stop logs between the piers at either end of the culvert.

PORT COLBORNE HARBOUR

This can be said to extend from the entrance between the breakwaters to Lock No. 8 and the supply weir.

As Port Colborne was the lake Erie terminus of the Third canal, the work comprised the deepening of the entrance channel and harbour, the construction of a new breakwater and the excavation of a new channel to Lock No. 8.

The outer harbour is formed by two breakwaters placed about 4,400 feet from shore, and a new breakwater extending as a spur from the old westerly breakwater out into the lake for a distance of 2,000 feet has been built to protect the harbour entrance against south-westerly gales.

The channel through the outer harbour has been deepened to 28 feet at low water and the inner harbour has been widened and deepened to the same depth.

The new breakwater, over 2,000 feet long, was formed of reinforced concrete cribs sunk onto a prepared rock bottom, then filled with rock and covered with a heavy concrete superstructure. It is further protected by a heavy rock embankment dumped on the southwest side.

The reinforced concrete cribs are 100 feet long by 50 feet wide and vary from 18 to 31 feet high. They were constructed at Port Maitland, about 20 miles west of Port Colborne, towed to the site, and sunk by opening valves in the bottom. A permanent reinforced concrete lighthouse has been built at the south end of the breakwater.

CANADA FURNACE COMPANY'S DOCK

Nine concrete cribs, built at Port Maitland, and towed to the site, were used in the construction of this dock, and as the new dock was 63 feet back of the original dock, it necessitated the shortening of the two unloading gantries.

CANADIAN NATIONAL RAILWAYS

The alignment of the new canal necessitated the erection of a new Canadian National Railways station and round-house at Port Colborne.

SOME IMPORTANT FEATURES OF THE CONSTRUCTION

CONSTRUCTION RAILWAY

To facilitate the movement of construction materials, and to carry excavated materials to Port Weller for the construction of the harbour, a standard gauge double-track railway was constructed and operated by the Government from Port Weller to the flight locks, a distance of about $7\frac{1}{2}$ miles.

The railway was equipped with complete interlocking and block signal system and a telephone train dispatching system. The traffic was extremely heavy when excavation was in full swing, as high as 384 trains being handled in one day.

The peak of activities was reached in 1927 when, with the northern end of the canal still under active construction, work was being carried on as well throughout the whole extent of the canal from lake to lake. During this construction season a total force of nearly 4,000 men was engaged.

ROCK CRUSHING PLANT

As limestone, well suitable for concrete, was found when excavating the canal prism between Lock No. 7 and Allandburg, a large rock crushing plant was erected by the contractors to crush this rock to sizes suitable for concrete. Most of the concrete in the locks was made from this crushed limestone.

SAND SUPPLY

Sand for concrete was obtained by dredging near the mouth of the Niagara river, and conveyed in scows to Port Weller Harbour where it was placed in bins and carried in cars over the construction railway to the points where it was required.

EXCAVATING PLANT

A great variety of excavating plant was used during the construction. The dry excavation was mostly done by shovels varying from the small steam shovel with $\frac{3}{4}$ cubic yard bucket on caterpillar tracks, to the large 90-ton machines with buckets up to 5 cubic yards capacity. A considerable amount of excavation was also done by dragline shovels, one of which of 5 cubic yards capacity was the largest used up to that time in Canada.

The dry excavated material was transported in a great variety of dump cars from the 4-cubic yard narrow gauge car to the 20-cubic yard steel air-dump cars. There were also trains of flat cars unloaded by means of Lidgerwood unloaders.

The subaqueous work entailed the use of floating drill boats, dipper dredges, clam shell dredges, and large suction dredges. These were tended by a fleet of powerful tugs and dump scows, the majority of the latter being of 500 cubic yards capacity.

BRIDGES

Twenty railway and highway bridges cross the canal, these being of four types, vertical lift, single leaf rolling bascule, double leaf rolling bascule, and swing, the majority (eleven) being of the vertical lift type with a clearance of 120 feet above the water level when fully raised.

The location and type of bridge at each crossing of the canal are shown in the following table:—

Bridge No.	Location name	Type	Kind of traffic	Width road-way	Channel width between piers	Weight of moving span and counter weights.	Notes
						tons	
1	Lake Shore Rd., Pt. Weller.	R.L.	Highway and S.T. Electric Railway.	17' 5"	80'3"	770	At Lock 1.
3	Carleton St.....	R.L.	Highway.....	20'	80'0"	530	At Lock 2.
4	Queenston St.....	Dble R.L.	Highway and Electric Railway.	30'	203'4"	2060	Kings Highway No. 8.
5	Merritton-St. Davids Rd.	V.L.	Highway.....	20'	200'0"	1240	
6	Can. Nat. Rlys. Main Line.	R.L.	Double Track Railway.	D.T.	80'11"	2064	Two single leaf rolling bascules at Lock 4.
7	Peter St., Thorold.	R.L.	Highway.....	20'	80'0"	530	At Lock 7.
8	Can. Nat. Elec. Rlys.	Swg.	S.T. Electric Railway.	S.T.	80'0"	450	
9	Thorold-Allanburg road.	R.L.	Highway.....	24'	80'0"	549	At Guard Gate.
10	Can. Nat. Rlys. Welland Div.	V.L.	D.T. Railway..	D.T.	203'1"	2245	
11	Allanburg.....	V.L.	Highway.....	30'	200'0"	1754	Kings Highway No. 3A.
12	Pt. Robinson.....	V.L.	Highway.....	20'	201'2"	1269	
13	Main St., Welland	V.L.	Highway and S.T. Electric Railway.	30'	216'4"	2080	
14	Lincoln St., Welland.	V.L.	Highway.....	20'	200'1"	1271	
15	Main Line, M.C. Railway.	Swg.	D.T. Railway..	D.T.	(100'1") (92'8")	1220	
16	Ontario St., Welland.	V.L.	Highway.....	260'	200'0"	1271	
17	Can. Nat. Rlys., Wabash Div.	V.L.	Railway.....	S.T.	200'0"	1160	
18	Forks Road.....	V.L.	Highway.....	20'	203'8"	1277	
19	Humberstone...	R.L.	Highway.....	20'	80'0"	530	Kings Highway No. 3.
20	Can. Nat. Rlys., Buffalo to God-erich.	V.L.	S.T. Railway...	S.T.	220'1"	1326	
21	Clarence St., Pt. Colborne.	V.L.	Highway.....	30'	220'9"	1919	

V.L.—Vertical lift.
D.T.—Double track.

R.L.—Rolling Bascule.

Swg.—Swing.

S.T.—Single track.

All bridges are operated by electric motors capable of opening them to their full extent in $1\frac{1}{2}$ minutes, and gasolene motors are provided as standby power should the electric current fail at any time. Bridge No. 12 was the last one to be built, and was placed in commission at the opening of navigation in April, 1931. All bridges were built by Canadian bridge building firms.

As these bridges carried all the east and west traffic arteries of the peninsula across the canal, their construction had to be so arranged that no delays were caused to railway and highway traffic, nor to the movement of ships navigating the Third canal.

HYDRO-ELECTRIC POWER PLANT

To provide the electric current required for operating all the lock and bridge machinery, for heating and lighting, a Hydro-Electric power plant has been built at the foot of the flight locks on the west bank, and was put into operation on November 4, 1932, supplying power to the whole of the canal.

Water is brought from an intake at the head of Lock No. 7 and is carried through an 8-foot 6-inch diameter reinforced concrete penstock, 6,000 feet long, built in the west walls of Locks Nos. 4, 5, 6 and 7 and carried on a footing behind the west wall joining Locks 6 and 7, with a resulting static head of 186 feet. The lower section of the penstock is lined with steel plate.

A motor-operated sluice gate, remotely controlled from the Power House, is provided at the intake, and pressure rises in the penstock are limited by a steel surge tank 210 feet high at the Power House.

Three 5,000-horsepower vertical shaft turbines, driving $66\frac{2}{3}$ phase generators, have been installed providing current at 6,600 volts, which is stepped up to 22,000 volts for transmission to the various parts of the canal.

TRANSMISSION LINE

The transmission line runs from end to end of the canal on the west side from Port Weller to Port Colborne. Sub-stations with step-down transformers are located at the locks and bridges to supply current at 550 volts for operating purposes.

MOTORS

In the regular daily operation of the canal the largest motor used on the bridges is 200 horse-power. The unwatering pump motors at Locks 1 and 8 are 225 horse-power. It has been found practicable to use only two sizes and types of motors to drive the various machines on the locks and weirs, a slip motor of 48.5 horse-power and a squirrel cage motor of 13.8 horse-power.

The canal is lighted from end to end so that traffic can be carried on both day and night. At the locks the lamps are placed on both sides and are spaced 160 feet apart along the lock walls and 200 feet apart on the approach walls.

The lighting of the long reaches between the locks presented several unusual problems but after exhaustive experiments a satisfactory unit was designed. These units are fixed on the transmission poles on the west side and are spaced at 450-foot intervals. They provide adequate illumination for both sides of the canal without causing objectionable glare.

HEATING

Electric heaters for use in the spring and autumn are installed in the lock buildings wherever required. In the winter when navigation is closed these heaters are sufficient to maintain a satisfactory temperature in the building.

TELEPHONE SYSTEM

A complete self-contained automatic telephone system has been installed along the canal linking the locks, bridges, substations, power-house and executive buildings.

FOREIGN WIRE AND CABLE CROSSINGS

As with the highways and railways, a large number of power, telegraph and telephone crossings had to be provided for.

For high voltages, crossings are made overhead on structural steel towers, the spans being generally 400 feet and the lowest wires at least 150 feet above the water level. There are nine such crossings along the route of the canal.

At the locks, a large number of ducts have been built into the walls and floors of the structures for carrying these

public utilities across the canal. The ducts are leased at nominal rentals to the telegraph, telephone, railway and power companies.

There are also nineteen submarine cable crossings laid in trenches excavated across the bed of the canal.

PONTOON GATE LIFTER

For the removal and replacement of lock gates, a pontoon gate lifter of 500 tons capacity was provided. This gate lifter, the largest in the world, is towed from place to place by tugs, but is otherwise a self-contained unit.

The gate lifter is fitted with a steam boiler, equipped to burn oil or coal, supplying steam to a vertical compound condensing steam engine which drives a 200 K.w., 240 volts, direct current generator.

This generator supplies the power for operating the main gate hoists, auxiliary derrick, capstans, pumps, heaters, lighting, etc.

Trimming of the pontoon is accomplished by shifting water ballast by means of the pumps.

An auxiliary derrick has been provided on the pontoon, with a capacity of 25 tons at 90 feet radius, for hoisting the lock valves out of their wells and other useful purposes.

OPERATION AND TRAFFIC

As previously mentioned, the construction of the Ship canal had to be carried on without interfering with navigation passing through the Third canal. The various locks, bridges, weirs, reaches and short sections of the summit level were, however, made available for navigation as soon as they were sufficiently far advanced towards completion to be placed in commission.

The whole of the Ship canal channel from lake to lake was made available for ships of St. Lawrence canal size, with a maximum draft of 18 feet, on November 19, 1930.

On November 22, 1930, the last vessel, the *I.L.I. 102*, passed through Locks Nos. 11 to 24 of the Third canal. This event may therefore be taken as the end of navigation through the Third canal after an existence of forty-eight years. Its structures were excellent examples of cut stone masonry and its twenty-six locks have now joined those of the Second canal as mute evidence of the stone masons' skill of former days.

The first vessel to make a complete transit of the canal was the motor ship *Georgian* which passed down through Locks Nos. 7 to 4 on September 10, 1930. She was wrecked on Grand island, lake Superior on November 29, 1932. The *Georgian* was best known as the *Fordonian* which came to the Great Lakes from Glasgow in 1912 as one of the first seventy-six Diesel-engine equipped vessels in the world at that time. She was later known as the *Yukondoc*, but her name was changed to the *Georgian* in 1929, when she was acquired by the Northwest Transportation Company, of Midland, Ontario.

As it was not possible to build the eastern end of Dam No. 6, the raceway of Lock No. 7 and Weir No. 7 until the Third canal was abandoned, the construction of these works had to remain in abeyance until the flight locks and Lock No. 7 were fully completed, and permanently placed in commission.

The locks of the Ship canal being all in operation at the close of the 1930 navigation season, it was immediately decided to abandon the Third canal between Lock No. 3 and the Guard Gate of the Ship canal, and to proceed at once with the construction of the eastern end of Dam No. 6 across the Third canal, the raceway of Lock No. 7 and Weirs Nos. 6 and 7.

During the latter part of the navigation season of 1930, when the flight locks were in commission, and throughout the whole of the 1931 navigation season, all water for operating the flight locks had to be passed through Lock No. 7. This method of operation necessitated many dummy lockages of this lock.

As the construction of Pond, Dam and Weir No. 6 and its discharge channel down to Pond No. 3 were completed at the opening of navigation in 1933, and as the Power House was placed in commission on November 4, 1932, and has since then supplied the whole of the canal with power, the operation of the flight locks and Pond No. 6 has been carried on in a normal manner since the opening of navigation in 1933.

The maximum length of a vessel using the Third canal was 261 feet, and the maximum beam 44 feet, with a draught of 14 feet. Three such vessels can easily be accommodated in the locks of the Ship canal, which have a usable length of 820 feet and a usable width of 79 feet, with a depth of water over the sills of 30 feet. At present two such vessels are allowed in the locks at the same time.

At the opening of navigation in 1931, vessels of the St. Lawrence canal size only were allowed to pass through the canal with a draught of 18 feet.

On June 15, 1931, vessels up to 450 feet overall length and drawing 18 feet were permitted to transit the canal. On June 29, 1931, vessels up to 550 feet overall length were permitted to pass through the canal on a maximum draught of 18 feet. These dimensions obtained during the remainder of the navigation season of 1931.

At the opening of navigation in 1932, vessels 550 feet long and drawing 18 feet of water were permitted to transit the canal. On July 1, 1932, vessels up to 600 feet overall length and with a maximum draught of 22 feet were permitted.

When the Welland Ship Canal was officially opened on August 6, 1932, all restrictions as to length and beam of ships then sailing the Great Lakes using the canal were removed, but the draught of 22 feet then in force was maintained for the rest of the 1932 navigation season.

On May 5, 1933, authority was granted for the passage of ships up to 700 feet overall length, and 75 feet beam, and with a maximum draught of $23\frac{1}{2}$ feet. These dimensions are considerably larger than those of ships sailing the Great Lakes to-day and are moreover well below the present and ultimate capacity of the Canal, and therefore clearly indicate that a waterway is now provided across the Niagara peninsula that is not only adequate for the requirements of to-day but for those of years to come.

The navigation season of 1932 showed a considerable increase in traffic over previous years and exceeded by 15 per cent the maximum traffic through the Third canal, which occurred in 1928.

In 1928 the traffic amounted to 7,439,617 tons of freight and the total number of passages was 6,587.

In 1931, the first entire year that the Ship canal was in use from lake to lake, the traffic amounted to 7,273,866 tons, and the total number of passages was 5,810 of the 451 ships that used the canal in 1931, 31 were larger than St. Lawrence canal size vessels, and varied from 300 to 550 feet long. These boats carried 17 per cent of the freight that passed through the canal that year.

In 1932, 8,537,460 tons of freight were carried through the canal. The number of passages was 5,712. Of the ships that used the canal in 1932, 71 were larger than St. Lawrence canal size and varied in length from 300 to 633 feet. These boats carried 31 per cent of the freight that passed through the canal in 1932.

During the two and one-half years that the Welland Ship canal has been in commission, its operation has proved very satisfactory, all the equipment has functioned as required, and no appreciable delays have been experienced to navigation. Furthermore, the initial transits of the canal by the large lake freighters and passenger ships during the 1931 season fully demonstrated that adequate facilities for their proper accommodation have been provided.

The locks of the Ship canal are large enough to accommodate any ship afloat except the largest passenger liners and warships. Statistics show that 65 per cent of the vessels that passed through the Panama Canal during 1930 had a draught of less than 25 feet and 95 per cent had a draught of under 30 feet.

Docks have been built at different points along the canal for the use of municipalities, factories and works located near the canal. A dock 500 feet long with freight shed has been constructed at Homer, a short distance below Bridge No. 4 to provide freight facilities for St. Catharines and vicinity. A turning basin 350 feet long and 22 feet deep has been excavated opposite the dock. Similar facilities have been provided for Thorold, and a new dock 600 feet long has been provided at Welland.

In one marked respect the construction of the Ship canal differs vastly from the three previous canals. During the construction period it was realized that this great waterway would require, in operation, a larger measure of protection against one of the greatest sources of delay to the navigation of limited artificial waterways, that of cross winds. An extensive reforestation program was therefore carried on during the later years of construction. Vast numbers of trees indigenous to the district have been planted, and these are now fast maturing into trees which will form a windbreak and by the aid of which navigation will be greatly facilitated during wind storms. Thus, what might have been a quaint commercial waterway is being transformed into a zone of natural scenic beauty.

THE OFFICIAL OPENING

On August 6, 1932, the Welland Ship canal was officially opened by His Excellency, the Right Honourable the Earl of Bessborough, Governor General of Canada, in the presence of many members of the British Empire Economic Conference, which at that time was sitting at Ottawa. A detachment from the Royal Canadian Regiment acted as a Guard of Honour.

The ceremony took place at the north end of the centre wall of Twin Lock No. 6, where a pavilion for the accommodation of the delegates had been provided on the roof of the control house. From this point certain of the delegates, in the order listed below, made addresses. The proceedings and addresses were broadcast by radio throughout Canada and the United States.

Hon. R. J. Manion, Minister of Railways and Canals, Canada.

Right Hon. R. B. Bennett, Prime Minister, Canada.

Right Hon. Stanley Baldwin, Lord President of the Council, Great Britain.

Right Hon. Stanley Bruce, Minister without Portfolio, Australia.

Hon. J. G. Coates, Minister of Public Works, New Zealand.

Hon. N. C. Havenga, Minister of Finance, South Africa.

Hon. Sean Lomass, Minister of Industry and Commerce, Irish Free State.

Hon. L. E. Emerson, Minister of Justice, Newfoundland.

Hon. Sir Padamji Ginwalla, Past President, Indian Tariff Board, India.

Hon. H. W. Moffatt, Premier, Southern Rhodesia.

After the addresses had been delivered, His Excellency the Right Honourable the Earl of Bessborough officially opened the canal by turning a lever and declaring these words: "It is a privilege to dedicate this Canal to the trade of the world. I hereby declare the Welland Ship canal open to the commerce of the world."

The movement of the lever caused the fender protecting the gates of the east chamber of Lock 6 to open, and the ss. *Lemoyne* (Captain C. E. Robinson) which was waiting in



